Art. XVIII.—*Contributions to our Knowledge of Australian Earthworms.*

The Alimentary Canal—Part I.

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(With Plates XLVIII.-LI.).

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The following work has been undertaken at the suggestion of Professor Spencer as a part of a general investigation into the structure of Australian earthworms now being carried on in the Biology Department of the Melbourne University.

It deals with the structure of the alimentary canal in the following species, the generic names of which are those adopted by Beddard in his "Monograph of the Order of Oligochaeta," and in Michaelsen's later work.[1]

1. *Megascolex dorsalis.*
2. *Megascolex fielderi.*
3. *Megascolex tenax.*
4. *Cryptodrilus saccarius.*
5. *Fletcherodrilus unicus.*
6. *Diporochaeta bakeri.*
7. *Diporochaeta tanjilensis.*

I have divided the work into two sections; the first dealing with the structure of the canal, and the second with special features in the different species examined.

Section I.

General Features.

A.—*Macroscopic Structure.*

In dealing with the alimentary canal, Beddard, whose nomenclature in regard to internal anatomy I largely follow, divides it into the following parts, viz.:—(1) Mouth, (2) buccal cavity.

1 Die fauna, Südwest-Australiens," 1907. Oligochaeta.

(3) pharynx, (4) oesophagus, and (5) large intestine. The gizzard is included in the oesophagus.

From the examination of the seven species of worms above named, I find that there is a definite portion immediately following the pharynx in all of them, which, so far as I can understand, has hitherto been included in the oesophagus, as its most anterior portion. I have found, however, its structure to be so different to the remaining portion of the oesophagus that I propose to distinguish it from the other parts as a separate portion, and as it resembles in position the "crop" of European forms, I intend using this term for this particular portion. It is always present, but is hidden from view in a median dorsal dissection, owing to the pharyngeal mass extending over it, and also because of the muscles connecting the latter with the anterior portion of the gizzard.

I also intend classifying the gizzard as a distinct portion of the canal, instead of including it as part of the oesophagus.

My division of the canal will therefore be as follows:—(1) Mouth, (2) buccal cavity, (3) pharynx, (4) crop, (5) gizzard, (6) oesophagus (including the so-called calciferous glands), and (7) large intestine.

(1) The *mouth* is overhung by the prostomium.

(2) The *buccal cavity* is thin-walled, with strands of connective tissue stretching from it to the inner surface of the body wall.

(3) The *pharynx* has a large muscular mass on its dorsal surface, which is seen in a vertical dissection to be partly glandular [Fig. 1]. The internal lining is folded dorsally, sending branches far up into the mass. There are strands of muscle reaching from the posterior dorsal region of pharynx to the anterior dorsal portion of the gizzard, and also to the sides of the body, across the coelom.

(4) The *crop* is the large dilated portion in front of the gizzard, and is seen in a median vertical dissection to be thin-walled and rather large for the space it occupies, so it generally appears to be slightly folded on itself. [Fig. 1.]

(5) The *gizzard* is thick-walled and occupies one segment only, i.e., the one following that in which the crop is situated. Beddard mentions in his "Monograph of the Order of Oligochaeta" that the genus Perichaeta is remarkable for the fact

that it is provided with only a single gizzard, which nevertheless occupies two segments. He thinks it quite possible that in this case there is really a pair of gizzards which have become fused to form a single one. I have found it occupying only one segment, the exact number of which is often difficult to determine, owing to the septa at this anterior region being very thin and lying close to the canal, and to each other.

(6) The *oesophagus* is the portion between the gizzard and the intestine. It varies very much in form from the simple thin-walled tube, which may be constricted at each septum, giving the canal a pouched appearance, to the forms where the calciferous glands are present, forming in some cases large bean-shaped diverticula. We must distinguish between those portions of the oesophagus which are pouched, because of the constrictions at the septa, and those portions which are actually swollen out in the segments. The former I refer to in the description as "simple," the latter as "vascular swellings." They are easily distinguished macroscopically by their walls, the vascular swellings having a rough-looking surface owing to their inner lining being folded, and, generally speaking, being richly supplied with blood. The thin-walled, simple portions are generally in the anterior and posterior regions of the oesophagus, while the middle portion is modified in various ways.

Calciferous Glands.—The term "calciferous glands" seems to have been used in rather a loose sense, and often, where the alimentary canal of a certain worm is described as having calciferous glands, I have only been able to find vascular swellings. I have therefore restricted the term to *those swellings in the oesophagus which are not of the ordinary median kind*, i.e., *which are* NOT *simple vascular swellings. They may be sacculations of a vascular swelling* [Fig. 2], *or diverticula of the oesophagus* [Fig. 3]. It is not necessary that they should be separated from the median portion of the canal by a duct. Thus in *F. unicus* they are in the form of small pouches, varying in number in the different segments, and not separated from the median canal. It is just as if we had a large vascular swelling indented at different places, and so giving it a sacculated appearance. [Fig. 2.] So far as I have examined I find that where they are in the least separated from the canal by a constriction or a duct, they are paired.

(7) The *Large Intestine* forms the last part of the alimentary canal, reaching to the end of the body. It varies in the size of its lumen in the different specimens, but is easily distinguished from the oesophagus by its larger lumen and its lateral sacculations.

A very noticeable feature seen in the dissections of some of the species, such as *M. dorsalis*, *M. fielderi* and *D. tanjilensis*, is the presence of a large number of nephridial tubes attached ventrally in the region of the pharynx. They are in the form of bunches, one each side of the pharynx, and have generally been considered as "peptonephridia." The latter have been defined by Beddard as nephridia, opening into the anterior section of the alimentary canal, and functioning in relation to digestion. So far, however, as I have examined I have found them opening to the exterior, *not* into the canal. I cannot, therefore, regard them as peptonephridia, but simply as a specialized group of nephridia, the meaning of which is not clear.

B.—*Microscopic Structure.*

As regards the microscopic structure of the alimentary canal, we have much the same structure in the corresponding parts of the different species.

The presence of a cuticle is easily seen as far back as the end of the gizzard, and also in the intestine, but in the oesophagael region it is difficult to determine its existence.

I have only found cilia in certain restricted areas, viz., in the hinder portion of the oesophagus in the two species, *Megascolex dorsalis* and *Diporochaeta bakeri*, and in the calciferous glands of *Cryptodrilus saccarius*. They may be present in other regions besides these, but I have not examined enough specimens to state definitely the ciliated regions.

(1) The *mouth* leads into the buccal cavity.

(2) The *buccal cavity* is lined with a cuticle and large columnar cells. Connective tissue fibres stretch across the body space from the cavity wall to the body wall.

(3) The *pharynx* is lined by cuticularized columnar epithelium, which is folded dorsally and sends ramifications up into the dorsal mass. In sections the mass is found to consist of an

inner muscular portion forming the thick dorsal wall of the pharynx, and an outer loose glandular portion lying on the muscular mass, and continuing back so as to overlie the crop. [Fig. 1.] The mass is richly supplied with blood vessels. In examining sections it is seen that the most anterior portion of the mass is entirely muscular [Fig. 4], the middle portion has a small amount of glandular tissue dorsal to the muscle [Fig. 5], and at the hinder end it is entirely glandular [Fig. 6]. I have not found any trace of a duct in connection with this glandular mass in any of the serial sections. The cavity of the pharynx is continued up into the mass, so the gland mass may be associated with the digestive system. On the other hand there is the extra supply of nephridial tubes in this region in some cases, so the mass may be associated with the coelom.

(4) The *crop* is thin-walled, and has its lumen slightly folded. The columnar cells are large, and a thin cuticle is visible. The muscular layer is thin, and there is a fair amount of connective tissue present with blood vessels. [Fig. 7.]

(5) The *gizzard* is strongly cuticularized, and is of the ordinary structure, i.e., has a great development of circular muscle fibres, and very few transverse.

(6) The *oesophagus* is very richly supplied with blood in certain regions, and the columnar epithelium is drawn into folds to varying degrees in the different parts. In the simple portions the folds are low, and then they increase in size as the oesophagus becomes modified. The structure of a vascular swelling with long folds is represented in Fig. 8.

In the calciferous glands the lining is drawn into very long fine folds, with a very large blood supply [Figs. 2 and 3].

The muscular tissue is not very strongly developed in the oesophagael regions, but the two layers—longitudinal and circular—can generally be distinguished.

The peritoneal epithelium varies in thickness in different places. It is generally made of granulated cells of a fair size in the vascular swelling region [Fig. 8], but in the calciferous glands it is a very inconspicuous layer.

(7) The *large intestine* has the usual layers present, which, however, differ in thickness at the anterior and posterior regions respectively. At the anterior end the muscular tissue is only

slightly developed, and the peritoneal layer is large, and made of very granular cells with large nuclei. At the posterior end, the muscular tissue is more strongly developed, and the peritoneal layer is represented by a thin membrane. I have found no trace of a typhlosole in any of the specimens examined so far.

Section II.

Description of Special Features in Species Examined.

As the structure of the pharynx and buccal cavity appears to be the same in all the specimens examined, except as regards the presence of special nephridia in some forms, as described above, I have not referred to those parts in the following descriptions: —

1.—Megascolex dorsalis, Fletcher.

Perichaeta dorsalis, Fletcher. Proc. Linn. Soc. N.S.W., vol. ii., 1887.

Plate L., Fig. 10 and Fig. 9.

(a) *Macroscopic.*—Buccal cavity and pharynx extend to end of segment 4. Crop in 5. Gizzard in 6. Oesophagus runs from segment 7-16. It is simple in 7 and 16, and dilated into vascular swellings in 8-15. Large intestine commences in 17 and is pinched in slightly at each septum. Special bunches of nephridia are situated ventrally at the sides of the pharyngeal region. The description given by Mr. Fletcher differs slightly from this.

(b) *Microscopic.*—Oesophagus in segment 7 has its lining of columnar epithelium drawn up into deep, wide folds. There is a large development of circular muscle fibres. Patches of apparently glandular tissue surround this part of the oesophagus. The structure of the oesophagus in the vascular swellings varies in the different segments. In the first two or three the lining is folded only slightly, and the muscular tissue is reduced very much. In the following swellings the folds increase in length, the muscular tissue becomes strongly developed, and the peritoneal cells form a deep layer, until in segments 13-15 we get the structure seen in Fig. 8. In the simple portion of the

oesophagus, in segment 16, the lining resembles that in segment 7, but here there is a deep layer of peritoneal cells, and also the lining is ciliated, this being one of the restricted places in which I have found cilia [Fig. 9].

2.—**Megascolex fielderi**, Spencer.

Perichaeta fielderi, Spencer. P.R.S. Victoria, 1892.

Plate L., Fig. 11.

(a) *Macroscopic.*—Buccal cavity and pharynx in segments 1-3. Crop in 4. Gizzard in 5. Oesophagus in 6-16; simple in 6-10, vascular swellings in 11-14, the one in 11 being small. In 15 and 16 the canal is simple and very vascular. Large intestine begins in 17, and has a large lumen. Special bunches of nephridia are present in the pharyngeal region.

This description differs slightly from that given by Professor Spencer.

(b) *Microscopic.*—In segments 6-10 the lining is thrown into deep, wide folds, and has goblet cells very largely developed in it. The circular and longitudinal muscle fibres are well developed, and there is a large blood supply. Vascular swellings, and simple canal in segments 15 and 16, similar to *Megascolex dorsalis*, but there are no cilia.

3.—**Megascolex tenax**, Fletcher.

Perichaeta tenax, Fletcher. Proc. Linn. Soc. N.S.W., vol. ii., 1887.

Plate L., Fig. 12.

(a) *Macroscopic.*—Buccal cavity and pharynx in segments 1-3. Crop in 4. Gizzard in 5. Oesophagus in 6-15; simple in 6-10 and 14-15, calciferous glands in 11, 12 and 13. The glands are paired and constricted off from the median canal by very short ducts. Large intestine begins in 16, the first portion in segments 16-24 being sacculated as usual, but beyond segment 24 there is a constriction in the middle of each sacculation.

(b) *Microscopic.*—Oesophagus in the simple portion has a narrow lumen, with small folds in the lining. The columnar

epithelium consists of short and long cells, alternating in groups. The muscle layers are distinct, and a fair blood supply. Calciferous glands are connected to the median canal by short ducts. The lining of the glandular portion is drawn into long thin folds, as in *Cryptodrilus saccarius.* (See below.) The muscular tissue is well developed, and there is a flat peritoneal membrane.

4.—**Cryptodrilus saccarius,** Fletcher. Proc. Linn. Soc. N.S.W., 1886.

Plate LI., Figs. 13, 17 and 18.

(a) *Macroscopic.*—Buccal cavity and pharynx in segments 1-3. Crop in 4. Gizzard in 5. Oesophagus in 6-14, being simple in 6-8, and also in 14. In 9-13 get five pairs of calciferous glands, each gland being separated from the median by a distinct duct of considerable length. The glands are bean-shaped, and each has a large vessel running along its length on the dorsal surface [Fig. 17]. Large intestine begins in 15, and is constricted in each segment at the septa.

(b) *Microscopic.*—Oesophagus has the usual structure in the simple portion. Calciferous glands show very long folds of the lining extending right across the lumen, and are richly supplied with blood. The lining here was remarkable in its columnar epithelium being ciliated, the cilia being visible with the low power [Fig. 18]. In the ducts, also, cilia are present, but they are much shorter here. A large number of goblet cells are mixed with the columnar. The median portion of the oesophagus in the calciferous gland region, has columnar epithelium not drawn into long folds, and shows a cuticle.

5.—**Fletcherodrilus unicus,** Fletcher.

Cryptodrilus unicus, Fletcher. Proc. Linn. Soc. N.S.W., 1889.

Plate LI., Fig. 14, and Plate XLVIII., Fig. 2.

(a) *Macroscopic.*—Buccal cavity and pharynx in segments 1-4. Crop in 5. Gizzard in 6. Oesophagus simple in segments 7 and

8, but swollen in 9-17. There are simple vascular swellings in 9-12 and 16-17, but in 13, 14 and 15 they form calciferous glands, paired in 13 and 15, but irregular in 14 [Fig. 2]. They are not separated from the median canal by a duct, but are like large vascular swellings constricted at different places. Large intestine at its anterior end has a small lumen, and is slightly constricted at each septum. After about segment 25 it is wider, and not constricted at the septa.

(b) *Microscopic.*—Oesophagus as far as segment 12 is of the usual type. The calciferous glands have thin walls and are very vascular. There is scarcely any muscular tissue, and the peritoneal layer is flat. The lining is drawn into long thin folds. The structure of the gland in segment 14 is represented in Fig. 2.

6.—Diporochaeta bakeri, Fletcher.

Perichaeta bakeri, Fletcher. Proc. Linn. Soc. N.S.W., vol. ii., 1897.

Plate LI., Fig 15.

(a) *Macroscopic.*—Buccal cavity and pharynx 1-3. Crop in 4. Gizzard in 5. Oesophagus is simple in segments 6, 7 and 8, and dilated in 9-14, dilatations being largest in 12-14. It is simple in 15 and 16.

Large intestine begins in 17.

This description differs slightly from that given by Mr. Fletcher.

(b) *Microscopic.*—Resembles *M. dorsalis.* The oesophagus in segments 15 and 16 has a ciliated lining.

7.—Diporochaeta tanjilensis, Spencer.

Perichaeta tanjilensis, Spencer. P.R.S. Vict., 1892.

Plate LI., Fig. 16.

(a) *Macroscopic.*—Buccal cavity and pharynx in 1-3. Crop in 4. Gizzard in 5. Oesophagus in segments 6-16, being simple in 6-8 and dilated into vascular swellings in 9-16. Large intestine

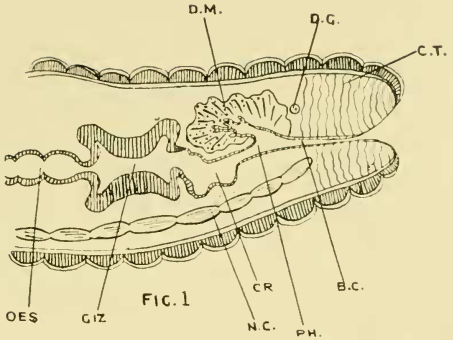

FIG. 1

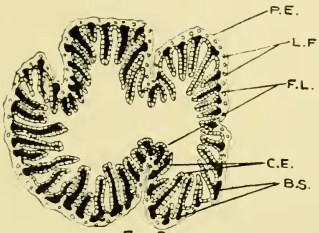

FIG. 2.

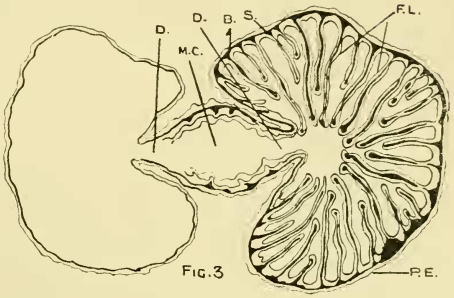

FIG. 3

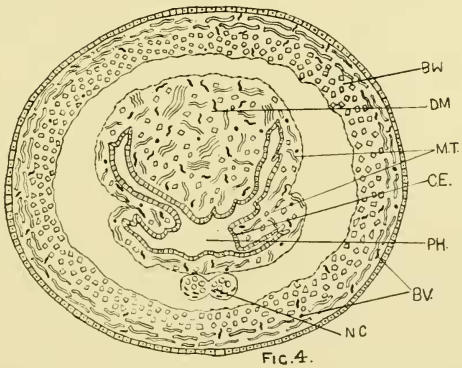

FIG. 4.